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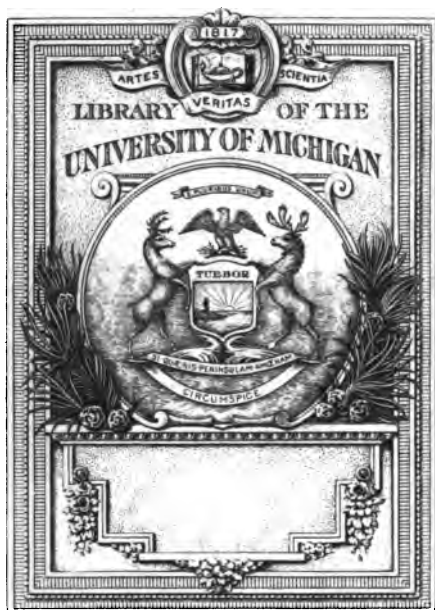
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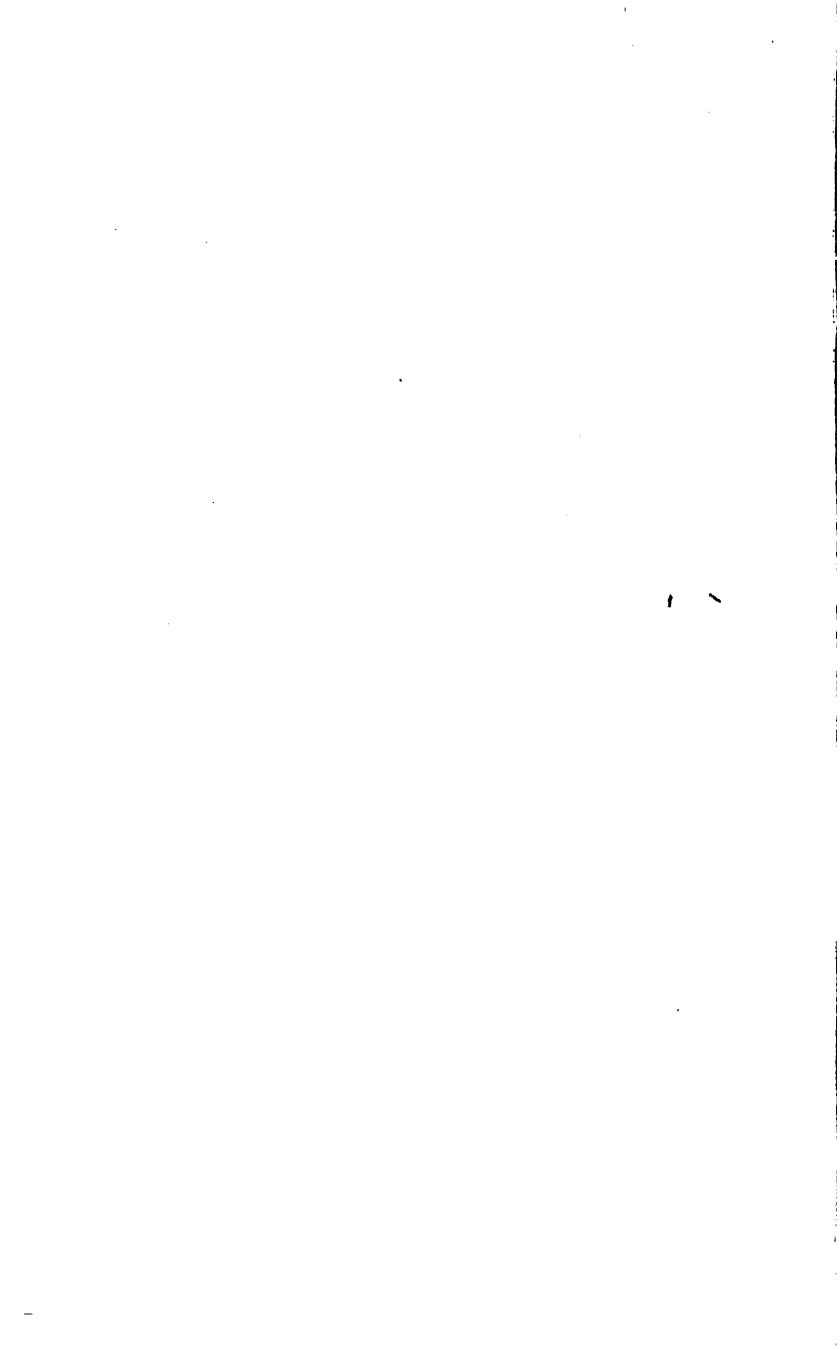
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ATHEISM AND ARITHMETIC;

OR,

MATHEMATICAL LAW IN NATURE.

ARITHMETIC IN PLANTS AND PLANETS.

MATHEMATICS IN MUSICAL SCIENCE.

NUMBER IN VITAL ACTION.

BY H. L. HASTINGS,

Editor of THE CHRISTIAN, Boston.

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PREFATORY NOTE.

The following pages were commenced as a brief introduction to a Lecture on *Number in Nature*, delivered at New College, London, by Edward White, and issued as the fourteenth number of the ANTI-INFIDEL LIBRARY. In attempting to elaborate more fully a few of the numerous points touched upon by the Lecturer, the Introduction speedily outgrew that which it was to introduce, and it was decided to publish it independently.

Though the instances which indicate the reign of Mathematical Law in the universe are so numerous and so intricate that no finite mind can ever fully investigate or comprehend them, yet it is hoped that the few examples here presented may suggest further research on the part of the thoughtful, and perhaps lead the careless and the perplexed to perceive in such facts as these, a line of proofs of the existence of an intelligent Creator, which, though too much neglected, are well worthy of their most careful attention.

God has not left himself without a witness, either in the order of the visible creation or in the constitution and instincts of the human soul. "He that cometh to God, must believe that he is, and that he is a rewarder of them that seek after him." The following pages call attention to a few of the instances of his wondrous working; and they are sent forth with the prayer that through their instrumentality the wandering and benighted may "seek the Lord, if haply they may feel after him and find him, though he is not far from every one of us. For in Him we live, and move, and have our being: for we also are his offspring."

H. L. HASTINGS.

Boston, Mass., U. S. A., March, 1885.

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ATHEISM AND ARITHMETIC;

OR,

MATHEMATICAL LAW IN NATURE.

BY H. L. HASTINGS.

CHAPTER I.

IS THERE A GOD? A WIDE-SPREAD SENTIMENT. THE UNIVERSE AN INVENTION. IS THERE AN INVENTOR?

Is there a God? Who knows, and who can tell? We know that *we* exist, but what do we know besides? No man hath seen God, and what evidence have we of the existence of an unseen Deity? Men have ransacked the world to find the abode of a Supreme Being, but He ever eludes their search. Neither in Olympus nor Zion, neither in the temples of Rome, or Greece, or Persia, or Babylon, or Assyria, or Egypt, has man been able to find the God for whom he has sought. There is no spot on the globe where the human eye can behold its Creator. Is it wonderful, then, that men doubt the existence of one who, if he exists, hides himself from their view?

Yet, notwithstanding all this, the mass of mankind, from the remotest ages, have believed and acknowledged the existence of a God,—a supreme, intelligent and almighty Ruler, or of some superior beings or powers to whom man is indebted for the blessings of this life and

the hope of a life to come. Said Plutarch, the greatest biographer of antiquity, more than 1700 years ago:

"If you will take the pains to travel through the world, you may find towns and cities without walls, without letters, without kings, without houses, without wealth, without money, without theatres and places of exercise; but there never was seen, nor shall be seen by man, any city without temples and gods, or without making use of prayers, oaths, divinations, and sacrifices, for the obtaining of blessings and benefits, and the averting of curses and calamities. Nay, I am of opinion that a city might sooner be built without any ground to fix it on, than a commonweal be constituted altogether void of any religion and opinion of the gods, or, being constituted, be preserved."*

This conviction is wide-spread. The appetite for religion is as universal as the appetite for bread, and as natural. It is true that many men make a living out of religion, but so do many men make a living by baking bread; but no one proposes to go without bread because bakers get their own bread by furnishing bread to others. It is equally true that there is much poor religion in the world, but there is also much poor bread; and if Pharaoh's baker baked no better bread than some men bake in these days, it is not strange that his master hung him. But people *will have bread*, though it be poor; and if the supply be scanty they still insist that "half a loaf is better than no bread." And so people *will have a religion*, though it may be small in quantity and inferior in quality. And this inclination for religion is not an acquired and debasing appetite, like the appetite for opium and tobacco; it is the spontaneous and universal uplifting of the soul to adore something higher and greater than mortal man;

* PLUTARCH, *Morals, Adv. Colotes*, 31, vol. v. p. 379. Boston, 1874.

and the higher the nations rise in virtue and excellence, the more firmly are they established in their religious convictions. And this appetite for religion is older than the priests, just as the appetite for bread is older than the bakers; the demand existed before the supply was provided. The instinct of worship is a natural instinct, indicating an actual need inwrought in the human constitution, for some wise purpose, by the Creative Hand.

A sentiment so wide-spread, so well-nigh universal, must rest upon some substantial basis. There must be some evidence which convinces men of the existence of a Power higher than themselves.

Every man sees things done around him which neither he nor any other man can do.* There are energies at work which he can neither control nor comprehend. He stands in the midst of a universe, every portion of which is in orderly, majestic, and unceasing motion. He tries in vain to find its source; he is baffled at every point. No matter what path he takes, or what clue he follows, he comes at last to a boundary which he cannot pass, and beyond which he can pursue his researches no further.

No mortal can explain the existence of matter, or the constitution of its primary elements. No person can unfold the origin of force, or learn the source of motion. No one can explain the origin of life, whether vegetable or animal. No one can explain the evidences of design and contrivance in the natural world. No one can unfold the methods of perception, the processes of thought, the origin of human speech and language, or the mysteries of the human will.

Learning and intelligence, literary investigation and

* All sensible things which are apprehended by opinion and sense, are in the process of creation, and are creative. Now that which is created must of necessity be created by a cause. But how can we find out the Father and Maker of all this universe? or when we have found him, how shall we be able to speak of him to all men?"—PLATO, *Timæus*, 28.

scientific research, are all futile in such fields as these; and men must either confess their ignorance, or invent big words to conceal it from other people who are confounded by high-sounding talk and who reverence men whose speech they cannot understand. But obscurity is not a certain indication of depth, for it is easier to see bottom through twenty fathoms of clear water, than in a wayside mud-puddle six inches deep. Learned verbiage conceals a vast amount of scientific ignorance. He who tells what he *does not know* in all the languages of Babel, is listened to with profound respect, while the man who tells what he *does know* in language which people can understand, is hardly supposed to be worthy of notice.* And there are persons who accept without question the assertions of scientific men, much in the spirit of the old Scotch woman, who when asked if she could comprehend the minister whom she had been praising, replied, "Comprehend him! *I wouldna hae the presumption!*"†

Superstition, with her fables and babblings, fails to satisfy man's curiosity and solve his doubts, and leaves him, as does science, involved in perplexity and uncertainty.

Man wanders in a world which he cannot understand. He catches a few gleams of sunshine, and again he is wrapped in clouds of gloom; to-day he basks in light, and at night he is shrouded in darkness; now all things

* For example, one of these scientific guides is quoted as saying: "Evolution is a change from an indefinite, incoherent, homogeneity, to a definite, coherent, heterogeneity, through continuous differentiations and integrations;" "which being interpreted" by the mathematician Kirkham, reads in plain English thus: "Evolution is a change from a nohowish, untalkaboutable all-alikeness, to a somehowish and in-general-talkaboutable not-all-alikeness, by continuous somethingelifications and stick-togetherations."

† Said the Hon. CHAUNCEY M. DEFEW, when replying to a eulogy on Free Thought delivered before a New York audience: "I confess I do not understand these evangels of free thought. They use a language of strange terms and beautiful generalities which convey no meaning to me. Here and elsewhere I have listened with the most earnest attention; but when they have tumbled down my church and destroyed all the foundations of faith, they offer in return *only phrases, collocations of words, and terminologies as mixed as chaos and as vague as space.*"

speak to him of beauty and beneficence, and again he finds himself submerged beneath seas of trouble; one day he is charmed by the rainbow hues of hope, and the next day he is buried in the shadows of darkness and despair; to-day he has health, to-morrow he has pain and suffering; now he beholds men rejoicing in the vigor of conscious life, and again he sees them stricken by disease, and smitten by the hand of death; sometimes right prevails, again iniquity and hypocrisy triumph; to-day good seems to be omnipotent, and to-morrow evil seems triumphant; and with all these mysteries around him, is it strange that he sometimes doubts the existence of any higher and diviner Power? Is it wonderful that he loses hope and heart, and that, perplexed with the present, and uncertain of the future, he sinks into hopeless apathy, saying, "Let us eat and drink, for to-morrow we die"?

And yet, notwithstanding the apparent discordance and disorder which appears in the world, a moment's consideration will indicate that this universe in its normal condition is ordered and controlled by wisdom and beneficence. Health is the natural condition of man; disease usually comes through needless and sinful interference with the established order of things. There is more of health than of sickness; there is more of happiness than of misery; there is more of enjoyment than of suffering; and, moreover, pain has its beneficent uses, in guarding against excess, and protecting what would otherwise be destroyed.

The contrivances and adaptations of nature are uniformly beneficent; we find no devices or arrangements in the universe which naturally tend to produce pain, suffering, trouble, and distress. The human machine, run as it was *made* to be run, runs smoothly; it is only when men carelessly or willfully throw it out of

gear, that it goes wrong. The operations of the human mind in the vast majority of instances minister pleasure and blessing; it is only those who have deranged, perverted, and misused their powers, who are at war with their environment, and who regard life as a curse. Sickness, pain, suffering, are regarded as indisputable proofs of *disorder*; but if this world were controlled by cold unsympathizing *force*, pain and disorder might be as natural and as constant as pleasure and order are now. And if some malevolent intelligence ruled over and controlled the world, we should then find that the *normal* condition of things would be one of *pain* and *discomfort*; eyes would ache when *well*, simply because they were maliciously *made to ache*, and every nerve and organ of the body might be expected to become an instrument of pain and torture. This is never the case; suffering only comes through wrong-doing, and *usually* through willful transgression of known laws.

And those who see disorder in this world, and hence deny the existence of creative wisdom and benevolence, should remember that this world is by no means in its primeval or normal condition. Every heathen nation has vague traditions of a golden age that is passed, and the most ancient records in existence explicitly declare that this world which was once very good, has, for wise purposes, and in consequence of human sin and rebellion, fallen beneath the curse of God, and become involved in calamity and distress. Hence the present disorder which the world exhibits must be recognized, not as its normal and permanent condition, but as the temporary result of the intrusion of evil into a realm otherwise harmonious and well ordered. But who is the great Ruler under whose dominion this world exists? Who has seen Him? Who can know Him? Who can find him out?



It is true the ancient world worshiped countless deities. Egypt had her hideous images, her sacred calves, and consecrated cats and monkeys and crocodiles, which her wise men worshiped and adored.* Assyria had her winged lions and human-headed bulls, which the spade of the explorer has recently brought to view. Babylon had her idols of silver and images of gold, which her proud rulers revered and honored. Persia had her gods of evil and of good, of light and of darkness. Greece had her magnificent temples, and her numerous deities haunted her classic groves, and presided over cities adorned with statuary, and temples filled with debauchery; Rome had in her Pantheon thirty thousand gods. And India to-day numbers her deities by hundreds of thousands. The very heavens and earth have been thronged for ages with deities, base, brutal, cruel, blood-thirsty and obscene, adored by some and derided by others; and so the world has been tossed to and fro on a sea of doubt and uncertainty; and what likelihood is there that man to-day will solve the problem of the ages, and arrive at certainty upon a subject about which humanity has disputed for centuries?

There are, however, a few things to be said in a general way regarding this matter. And first, it may be affirmed that mankind were not always in such darkness and uncertainty. In fact, it may be very safely said that humanity in its earliest ages did not accept these numerous forms of idolatrous worship which arose in later times; for it is demonstrable that most of the idols of the

* Who knows not, O Bithynian Volusius, what monsters crazy Egypt worships. One part of the people adores the crocodile; another trembles before an ibis glutted with serpents. The golden image of the sacred tailed-monkey shines among the effigies of the gods, where the magic chords resound from Memnon broken in twain, and ancient Thebes, with her hundred gates, lies overwhelmed in ruin. At one point they venerate fish from the sea; at another, fish from the river; at another, whole cities worship a dog: no one Diana. The leek and onion it is impious to dishonor and break with the teeth. O holy nations, for whom such deities grow in their gardens!—JUVENAL, *Satire*, xv. 1-11.

heathen are deified men, and consequently their heaven was peopled with gods which had once been inhabitants of the earth.*

There is another thought which is worthy of attention. The character of these heathenish deities was such that only persons of vile and corrupt instincts could have imagined or adored them. Only bad men could have exalted or worshiped the adulterers, the cut-throats, and the villains whose names stand blazoned on the pages of heathen mythology. And it is also true to-day that there are multitudes who know no God, and who *desire* to know no God, unless he be a God who will wink at their iniquities and sanction their transgressions. There are men who do not choose to know any God who is likely to interfere with their appetites, passions and desires, and who like best a world where they can be free from all restraint and responsibility, and so be a law unto themselves.

This frame of mind does not qualify people for careful and candid seeking after a God of purity and righteousness and truth. There are none so blind as those who will not see; and no man searches honestly for that which he is afraid to find. And there are multitudes who have no greater fear than that they will sometime in their history stand unveiled in the presence of an Almighty God, more holy than the purest instincts of their being which they have disregarded, and more clear-sighted than their

* Numa forbade the Romans to represent God in the form of man or beast, nor was there any painted or graven image of a deity admitted amongst them for the space of the first hundred and seventy years; all which time their temples and chapels were kept free and pure from images. To such baser objects they deemed it impious to liken the highest, and all access to God impossible except by the pure act of the intellect. PLUTARCH, *Lives*, vol. i. p. 138.

Is it not something worth knowing, worth knowing even to us after the lapse of four or five thousand years, that before the separation of the Aryan race, before the existence of the Sanskrit, Greek, or Latin, before the gods of the Veda had been worshiped, and before there was a sanctuary of Zeus among the sacred oaks of Dodona, one Supreme Deity had been found, had been named, had been invoked by the ancestors of our race, and had been invoked by a name which has never been excelled by any other name?—MAX MULLER, *Science of Religion*, p. 27.

highest intuitions which have ever disquieted them in their evil ways. Guilt ever seeks concealment. The first act of a sinner, conscious of wrong-doing, is to hide from offended Purity and Justice. The ancient record relates that the first sinners covered themselves with fig leaves, and then *hid* amid the trees of the Garden. So sinful man still shrinks from the eye of the Unseen One, but he cannot avoid His glance, nor escape his notice, for, while the sinful one hides, the Sinless One seeks him out, and in a voice of pity, compassion, and reproof says, "*Where art thou?*" Man trembles at that voice, and as the ostrich hides its head to shut out the sight of its pursuers, so men bury their heads in "Nature," and "Science," and "Law," and say, "There is no God; all is chance, everything is governed by Law, and Nature is supreme."

But what *is* this "Nature," of which people speak so fluently? What are the laws of Nature? Who gave these laws, and who enforces and executes them? These are questions which skepticism never answers, but goes its way and leaves us sitting in the darkness, under the shadow of an everlasting "somewhat," without joy or

* It is high time that philosophers, both physical and others, should come to some nearer agreement than seems to prevail, as to the *meaning they intend to convey* in speaking of causes and causation. On the one hand, we are told that the grand object of physical inquiry is to explain the nature of phenomena by referring them to their *causes*; on the other, that the inquiry into "*causes*" is altogether vain and futile, and that science has no concern but with the discovery of *laws*. Which of these is the truth? Or are both views of the matter true *on a different interpretation of the terms*? Whichever view we may take, or whichever interpretation we may adopt, there is one thing certain,—the extreme inconvenience of such a state of language. This can only be reformed by a careful analysis of the widest of all human generalizations, disentangling from one another the innumerable shades of meaning which have got confounded together in its progress, and establishing among them a rational classification and nomenclature. . . . A "*law*" may be a *rule of action*, but that is not *action*. The great First Agent may lay down a rule of action for himself, and that rule may become known to man by observation of its uniformity; but, constituted as our minds are, and having that conscious knowledge of *causation* which is forced upon us by the reality of the distinction between *intending* a thing, and *doing* it, we can never substitute the "*rule*" for the "*act*."—Sir JOHN HERSCHEL, *Address to the British Association*, 1845.

hope. Athens erected her altar, and inscribed upon it, "*Agnosto Theo*," to the *Unknown God*. But modern skeptics, too blind to discern the tokens of a Creator in a world which he has made, and too irreverent to adore that unseen Power which the ancients dimly recognized, pride themselves on their ignorance and *agnosticism*, and then keep up a ceaseless babblement of big words which they cannot define, but which they use to discuss matters which they do not understand, confusing others with mere sound, and wrapping about themselves the shadows of doubt and uncertainty, which shroud the present with the "mist of darkness," and robe the future in impenetrable gloom.*

Though the world by wisdom knows not God, yet the invisible things, since the creation of the world, are clearly seen, being perceived through the things that are made, even His everlasting Power and Divinity, so that men are left without excuse. Nature, in all its length and breadth, teems with manifestations of some incomprehensible and almighty Force, which exhibits itself in every department of the universe. Thus we may recognize the *Physical Force* which upholds all things, which marshals the stars, and binds the planets, and holds them in their course; the *Vegetative Force*, which throbs in every swelling seed, and changes the face of Nature, and carries on the unceasing processes of vegetative growth; the *Vital Force*, which pervades the animate creation, and exhibits itself in the growth and perpetuation of the

* The phrase, "undifferentiated protoplasm," as contrasted with "differentiated protoplasm," is now often used. Children are asked questions about it in elementary examinations, and yet *no exact meaning has ever been given by any one to the terms*, and the sense in which the words are often used is incorrect. The "differentiation" of protoplasm is one of the cant terms of the time, and is supposed to explain a great deal, while it *only deceives and confuses*; for instead of differentiation being an explanation of change or cause of change, it is really only a way of stating a fact.—*Dictatorial Scientific Utterances, and The Decline of Thought*, by LIONEL S. BEALE, F. R. S., p. 13.

myriad forms of animated existence: and over and above all these, there may be also discerned an *Intellectual Force*, which orders, ordains, and plans the whole scheme and system of the visible creation.

No stream can rise higher than its fountain; from nothing, nothing comes. Dead parents cannot produce living children. A man born blind could not invent an eye, nor could a man who had never heard a sound produce or contrive a musical instrument. A man who had never seen a ray of light could not paint a rainbow, nor could a man ignorant of simple addition construct a machine that would solve the most abstruse problems in mathematics. It requires skill to construct; it requires a still higher type of intelligence to *invent*. Conception and invention go before delineation and construction. The architect sees the house complete before a stone is laid or a timber hewn. The mind must contrive before the hand can combine. The idea of a thing must precede its existence; the plan must be conceived before the edifice can be erected.

- The universe around us is in itself an invention, and it is also filled with inventions, contrivances, and adaptations, and complicate yet orderly arrangements, which are not only beyond the constructive power of blind, unreasoning force, and changeless law, but are fraught with such mysterious evidences of intelligent design and purpose that man himself studies them for ages before he can comprehend their utility; and only through the accumulated researches and observations of successive generations does he learn by slow degrees to recognize "the manifold wisdom" of the Creator, and say with the devout astronomer, "O God, I think thy thoughts after thee."

The visible framework of creation may be viewed as a

great and wonderful machine. Whether with the telescope man explores the mighty depths of the blue abyss of heaven, or with a microscope discovers a mimic universe in a water-drop, in all things great and small he sees the tokens of creative power and wisdom—the handiwork of an omnipotent Creator. Who invented such a world? Who planned it, constructed it, established it, adorned it, and still sustains it and guides it in its wondrous course? Who is this Great Inventor, this unseen One, the producer and controller of the universe? There can be but one such being, for the matchless harmonies of universal nature disclose the orderly arrangements of a single mind, without the endless contradictions and collisions which must result from opposing wills. It is true there are in this world evidences of irregularity, disorder, confusion, disturbance and interference with beneficent law, but these instances, while indicating the resistance of inferior wills or powers, do not affect the obvious conclusion that *over all* presides some high and mighty One which on the larger scale, and in the longer run, overrules, controls, and governs all. This being must be omnipresent, for his working is seen in every place. He must be invisible, for an Omnipresent Being, if visible, would render everything else invisible. From Him, throughout the whole vast universe, stream the mighty tides of moral, mental, vital, and vegetative Force.

The universe is the wondrous workshop where He displays his wisdom and manifests his might. Without his perpetual support all things would sink into confusion and dissolution. He clothes the grass of the field, he paints the lilies of the valley, he feeds the ravens, watches the falling sparrows, numbers the hairs of our heads, and manifests through all his vast creation tokens of

supreme wisdom, almighty power, and everlasting love. The wisdom which invents, and plans, and calculates, and contrives, and constructs, must be greater than the wisdom which merely perceives and comprehends the utility of the work when it is accomplished and exhibited. Man in his threescore years and ten slowly spells out a few sentences in the great book of Nature, but God has written all its ample pages with his own right hand. And if in looking closely at the world around us, we discern countless tokens of the wisdom and ingenuity of One who has wrought unnoticed, and whose wondrous skill we have been too blind to discern and too careless to comprehend; if we find in the very plants and trees, and in the whole natural world, indications of a marvelous sagacity, working upon the highest *mathematical principles* by methods which we have hitherto failed to notice, and which only the most careful observers have perceived and pointed out; and if we thus see throughout the realm of nature marks of a hidden wisdom, superior to all the wisdom of this world; shall we not thus learn to recognize the power and might of an unseen Creator, the vastness of whose works gives some faint indication of his eternal power and majesty, and the abundance of whose bounties testifies to us of his kindness, tenderness and love for the creatures He has made?

Nature is but the garment of Deity. Reason untwists a fringe, puzzles over a pattern, and investigates the frayed border of this royal robe, and slowly discovers some marks of wisdom and design in its wondrous texture; but faith looks up and adores the God who wove the whole magnificent fabric, spangled with the starry splendors of the skies, embroidered with auroras and rainbows and emeralds, and adorned with gems that gleam in the silent depths, unseen by human eyes.

CHAPTER II.

THE REIGN OF LAW. MATHEMATICAL PRINCIPLES IN NATURE. ARITHMETIC IN PLANTS AND IN PLANETS,—IN CELESTIAL TIME-KEEPING AND IN CHEMICAL SCIENCE.

We recognize in this universe the reign of Law. But law is not an Intelligence, law is not a Being, law is not a Power, law never made itself, law never can secure its own execution. Law is but the expression of the Intellect which framed it, of the Will which promulgated it, and of the Force which energizes and executes it; and in the reign of Natural Law we cannot fail to discern the indications of a supreme Intellect, an omniscient Deity.

Leaving, then, for the present, the countless evidences of power, ingenuity, and adaptation, manifested in the construction of the visible universe, let us glance at some of the underlying principles which govern the world in which we live. The *laws* according to which this world is constructed and ruled are mathematical laws. The stability, order and perpetuity of the universe are secured in accordance with the principles of mathematical science. Men may not know or admit this fact, but this is because they are uninformed and unobservant. For ages men did not know that they walked this earth under an atmospheric pressure of 2,160 pounds on every square foot, or that the viewless air rests with a weight of 49,089,600 lbs., or 47,044½ tons, on every acre of the soil. Men have moved for ages in the midst of marvels unseen and unrecognized, and there are still more things in

heaven and earth than ever have been dreamed of in their philosophy.

For there are mysteries in the realm of natural science which still elude the research of the wisest. They have not yet learned "the balancing of the clouds, the wondrous works of him who is perfect in knowledge." "Great things doeth He, which we cannot comprehend." Job xxxvii. 16, 5. Job knew in his day that God had made "the weight for the winds," though it was ages before Torricelli proved it with his barometer. He knew that God "hangeth the earth upon nothing" ages before philosophers and priests ceased to declare that it was borne upon the shoulders of Atlas. Job xxvi. 7; xxvii. 25. The latest discoveries of science verify the earliest utterances of revelation. But the wise men of this age, with all their science and acuteness, have not yet learned the answers to the questions on natural philosophy contained in the book of Job. If one of them be asked, "Canst thou send lightnings, that they may go and say, Here we are?" they may now, after more than three thousand years of research, be able to say, "We can do it." But if the scientist be asked, "Dost thou know the balancing of the clouds, the wondrous works of Him who is perfect in knowledge?" or "By what way is the light parted, that scattereth the east wind upon the earth?" (Job xxxvii. 16; xxxviii. 24, 35), he can give no answer to such questions. Science has indeed learned to "part" the rays of light, and untwist its rainbow hues, but it has not yet learned what the parting of the light has to do with scattering "the east wind upon the earth." Science has only begun to collect its facts, and work its way among the mighty mysteries that pervade the visible creation. Nothing is more absurd than the supposition that a man who claims to be scientific has mastered the whole circle of knowledge, and that what he does not know is hardly

worth considering. The circle of knowledge is too vast for one man, or all men, to fully comprehend it.

Dr. Robinson, Astronomer Royal of Armagh College, Ireland, related in a lecture, that when a student in Trinity College, Dublin, he and a fellow student, a lover of nature, cut a foot square of sward from the College Park and agreed to study and examine it together. To their amazement, it took no less than six weeks to separate its various contents, vegetable, animal and mineral; and from the press of other pursuits they were obliged to abandon the undertaking, leaving unsettled a multitude of questions which arose from the examination of those materials and their history and relation to each other. Those men were investigators. But many who know nothing whatever of such subjects are ready to give credence to the wild guess-work of some scientific prophet, whose assertions broaden in proportion to the narrowness of his field of view. Thus men theorize concerning the formation of worlds, when they do not even know the material of which they are composed; and map out with all exactness the history of a globe of which they have never investigated one millionth part.* In all departments of scientific investigation, men are confronted by ten thousand mysteries which mortal life is too brief to solve, and which need but the researches of the countless ages of eternity to lead us to exclaim, "Oh the depths, both of the wisdom and the knowledge of God! How unsearchable are his judgments, and his ways past finding out."

But though the deeper mysteries of the universe are yet unexplored, there are some primary lessons in the great book of Nature which are so simple as to be within the comprehension of a child: and there are proofs of

* See *The Errors of Evolution*, by ROBERT PATTERSON. ANTI-INFIDEL LIBRARY, Nos. 10-13.

creative Intelligence, working *according to mathematical law*, throughout all the realms of animate, organic, and inorganic nature. The simplest illustration will make this palpable to any candid mind.

ARITHMETIC IN A CORN-FIELD.

If we plant a grain of maize, or Indian corn, and watch it as it grows, we see numerous indications of design and adaptation at every stage of its development. First, we observe a sharp-pointed stem pushing downward into the earth; second, a sharp-pointed spire pushing upward, piercing the soil above, struggling up to the daylight, and then unfolding itself in broad, spreading, funnel-shaped leaves, which catch the falling rain and the dew-drops, and convey them down to the centre of the plant. The corn-stalk, covered with a polished and impervious surface, and filled in the interior with a soft, porous, pithy substance, is an example of stability conjoined with lightness and economy of material. From the centre shoots up a single spire, or stalk, crowned by a tassel; while beneath it, and outside the branching leaves, appear the ears of corn, from the tops of which issues a silken fringe, in just the position to catch the pollen, which falls from the tassel above and renders the grain fruitful. Beneath this silken fringe we find the ear of corn itself, closely wrapped in an impervious envelope of carefully-folded husks, which protect it from storm and depredation while the soft and pulpy kernels grow and harden until they are fit to be exposed to the air, after which the covering dries and opens itself, that the sun may have access to the grain and perfect it.

Before we remove these grains of maize from the cob, and crush them between the mill-stones, let us examine them. We shall find that they are set in sockets, which are arranged in *straight rows* from the bottom to the top

of the central cob. Sometimes, if the grain is peculiarly unthrifty, there are but four of these rows, sometimes there are *eight*, sometimes there are ten, twelve, fourteen, sixteen, and even *twenty-four* rows of kernels arranged around the central shaft, or cob. But we *never* see *five* rows, or *seven* rows, or *eleven* rows, or *thirteen* rows of kernels on a cob. However the number may vary, it is an *even* and a permanent number. It is said that a miller declared that for twenty-seven years, while grinding corn, he had been looking in vain to find *one ear* containing an uneven number of rows of kernels.*

Now this *numerical order* in the arrangement of the rows upon countless millions of ears of corn, continued in different countries, and for successive centuries, cannot be the result of *chance*, for chance does not *count*, or know the difference between an even number and an odd one; and there are just as many odd numbers as there are even, and just as many chances for an odd number of rows as an even number. If the chances do not run evenly it is because some unseen hand manipulates them, some unseen will controls them. And that will must be a will of an intelligent Being who counts and reckons, and who understands what no mortal can comprehend,—how to rule the secret energies of vegetative life in accordance with mathematical law.

We can conceive no reason why those independent grains are any better for being set in rows which grow in

*It has been said that there is a variety of maize which has *nine* rows on the ear: this, if true, does not at all invalidate the argument, because if some special variety *uniformly* produces *nine* rows, it must be in obedience to the mandate of some mathematical Lawgiver; for mere chance could not ensure uniformity, whether the numbers were odd or even.

A story is told of a slave who, on being promised his freedom if he would find an ear of corn having an odd number of rows of kernels, went into the corn-field and carefully opening the husks on a number of ears, deftly cut out a row of kernels from each, closing up the husks over the ears again. The corn grew and ripened, closing up in its growth the vacant spaces, and when it was gathered he found an ear with an odd number of rows, and presented it and claimed the promised boon!

pairs. So a woman might not be able to give any definite *reason* of utility for putting two rows of buttons up and down a child's garment instead of one; but no person of common sense would say that two orderly rows of buttons came upon the garment of a child by blind chance; because the fact of their being in *rows* indicates design, and the fact that they are in *two* rows, indicates that they were put there by some one who counted, and measured, and had an eye to symmetry and beauty of appearance.

Chance might mix and shake and shuffle buttons to all eternity, without arranging two orderly rows of them upon a boy's jacket; and so chance might toss and tumble all the vegetation in the universe for ages, without producing one ear of corn with its kernels arranged in regular rows. But the kernels of corn are here, and they have been arranged by some one who has an eye for symmetry and order, and who can reckon and count.

Sometimes we find an ear of corn the kernels of which do not seem to be in regular rows, but which appear to be thrown together at hap-hazard; and it might be that an excessive luxuriance would sometimes crowd the kernels out of their regular order; but if we follow *around* the ear of corn, we shall find that such rows of kernels are arranged in *spirals*, rather than in straight lines; but still there is an even number of rows.

Now this is but a single and very simple illustration of a certain principle which pervades the universe around us, and which can be observed in thousands of growing plants, and thousands of other things, and indicates that the world was not flung together by chance, nor churned out of chaos by blind unreasoning force, but that it was built upon a certain plan, by a wise and foreseeing Creator, whose designs involved purpose, utility, order, symmetry and beauty.

But this purpose, order, symmetry and beauty is also *wrought out* in accordance with *mathematical law*, and the simplest of nature's works reveal the presence of a designing, contriving, *numerating* mind; while further study into its more complex designs, discloses other mathematical principles, more subtle, deep, mysterious, and far-reaching, than those which lie upon the surface of things, and are within the comprehension of a child.

ARITHMETIC IN PLANTS AND IN PLANETS.

Let us consider another law of vegetation, which is termed *phyllotaxis*, that is, the law of leaf-arrangement. If the leaves upon a stem were arranged by chance, they might sometimes be all upon one side of the stem, and sometimes upon the other side; or they might be arranged in one or two rows from top to bottom, each leaf standing exactly above the first leaf in the row.

There would, however, be a difficulty in the way of this arrangement,—leaves cannot grow properly without light and air; and by this arrangement the upper tier of leaves would get all the light, while the lower ones would be in perpetual shade; hence, though this plan might commend itself to some of those geniuses who think they could improve upon the making of this world, yet practically it would not work well.

Of course, the *seeds* of a plant would need a liberal amount of sunshine to ripen them, and in accordance with this requirement we find that they are usually put at the top of the plant, where nothing can shade them. But while it would also seem necessary that the leaves of a plant should shoot out in various directions, so that the tree would not become one-sided and tip over, yet to so arrange them as to give each leaf a *fair chance at the light* which comes from above, would require somewhat careful planning. And as this is something about which

chance would know nothing, care nothing and do nothing, if anything is done to meet this obviously important condition of things it must be done by *design*. What has been done? The answer to this question might fill a chapter.

The early geometers, thousands of years ago, undertook to mark out a *pentagon*, or five-sided figure within a circle. In endeavoring to do this, they were obliged first to divide the circle into two parts, one of which is a fraction *less* than 382 thousandths of the circle, the other is a fraction *more* than 618 thousandths, the fractional difference between these two parts being of such a nature that it is impossible to represent it by figures. They accomplished their purpose by so dividing the whole that the *smaller* part should bear to the *larger* the same proportion that the larger bears to the *whole*; and reckoning from this basis they were able to effect the desired division. This method of division is described as "Extreme and Mean Ratio," and leads to a result more accurate than can be reached by any arithmetical calculation.

This division in "extreme and mean ratio" has been known and used in geometry from before the Christian era to the present day; but it was not until 1849 that any one suspected that this principle existed in nature. But if we go into the orchard and examine a young apple or cherry tree, or sprout, we shall find that its leaves are arranged around the stem *spirally* in series of *fives*, the fifth leaf, or bud, standing *directly above the first*. But this placing of five leaves at *equal distances* around the central stem of a plant, involves the ancient problem of the *pentagon*, and embodies the principle of "division in extreme and mean ratio," which is inexpressible in figures; and this principle is *continually employed* in nature, in so dividing the circumferences of plants, or stems,

that the leaves and branches may be evenly distributed around the stalk, thus giving each its fair and proper chance to catch the light and air from above, and also maintaining the balance and symmetry of the tree.

Starting from any leaf of any plant, as a zero, and counting around and upward till we find another leaf which stands exactly above the first; which in grasses will be the second, in sedges the third, in the quince and the raspberry the fourth, in the apple and cherry-tree the fifth, in the peach and pear the sixth, in the holly and aconite the eighth, in the rosettes of the houseleek and cones of the white pine the thirteenth, and in certain pine cones the fifty-fifth; we shall find the principles of mathematical law constantly exhibited in the distribution of these leaves. And we shall find that the number of *leaves* in a *series*, and the number of *turns* of the *spiral* before a leaf stands directly over the first, as a rule, are in all individual plants or trees of each species *exactly the same*. We can thus trace arithmetical arrangement in every tree and bough and plant around us. And we shall find each plant made upon its own plan, and its leaves in every instance regularly counted off, by this same Mathematical Mind. We are not, of course, to expect mathematical accuracy of division in every instance, any more than we should expect a parlor mirror to be polished like a telescopic reflector, or a jackknife to be finished like a surgical instrument; but we find the same mathematical *principles* governing the whole vegetable creation, and showing that long before geometers had invented division in "extreme and mean ratio," He who caused the earth to bring forth plants and trees, understood and acted not only upon the simplest methods of numeration, but also the most obscure mathematical and geometrical principles.

We copy from Prof. Cooke a table of the law of phyllotaxis is, as illustrated in a few instances; from which it will

be seen that even the fractions of a circle which occur in

LAW OF PHYLLOTAXIS OR LEAF-ARRANGEMENT.

Name of Plant.	Number of Turns of Spiral.*	Number of Leaves.*	Fraction.	Angle of Divergence between two Successive Leaves.
Grasses, ...	1	2	$\frac{1}{2}$	180°
Sedges, ...	1	3	$\frac{1}{3}$	120°
Apple, }	2	5	$\frac{2}{5}$	144°
Cherry, }				
Poplar, }	3	8	$\frac{3}{8}$	135°
Holly, }				
Calistemon, }				
Aconite, }	5	13	$\frac{5}{13}$	138° 28'
Rosettes of Houseleek }				
Cones of White Pine, }	8	21	$\frac{8}{21}$	137° 9'
Cones of Europ'n Larch, }				
Certain Pine Cones, .	13	34	$\frac{13}{34}$	137° 39'
Certain Pine Cones, .	21	55	$\frac{21}{55}$	137° 27'
Typical arrangement which would expose to the Sun's rays the greatest leaf-surface,				137° 30' 28''

*Before a leaf stands directly above the first.

the arrangement of the leaves around a stem, are of a very peculiar character. After the first and second fractions, $\frac{1}{2}$ and $\frac{1}{3}$, the *third* fraction is formed by adding together the numerators of the two preceding fractions for a new numerator, and the denominators for a new denominator, thus giving $\frac{2}{5}$, and so on. But this *same peculiar series of fractions* is found to be embodied in the orbits of the planetary world. Thus in the language of Professor Cooke, "In the solar system, for example, with the exception of Neptune, the intervals between the orbit of Mercury and the orbits of other planets go on doubling, or nearly so, as we recede from the sun. Thus the interval between the Earth and Mercury is nearly twice as great as the interval between Venus and Mercury; and the interval between

Mars and Mercury is nearly twice as great as that between the Earth and Mercury, and so on. Again, if we compare the periods of the revolutions around the sun, expressed in days, we shall find another simple numerical relation, as shown by the following table:”*

LAW OF PERIODIC TIMES IN PLANETARY REVOLUTIONS.

	Observed.	Theoretical.	Fractions.
Neptune.	60,129	62,000	
Uranus	30,687	31,000	$\frac{1}{2}$
Saturn.	10,759	10,333	$\frac{1}{3}$
Jupiter	4,333	4,133	$\frac{1}{4}$
Asteroids. . . .	1,200 to 2,000	1,550	$\frac{1}{5}$
Mars.	687	596	$\frac{1}{6}$
Earth	365	$366\frac{8}{13}$	} $\frac{8}{13}$
Venus.	225	$227\frac{13}{21}$	
Mercury	88	87	

Here, then, we find in the plants beneath our feet and in the stars above our heads, evidence not only of unity of design and contrivance as indicating a common designer, but also of a knowledge of abstruse mathematical principles which it took geometers thousands of years to discover, and thousands of years more, after they were discovered, to find out that they were already embodied in all the plants and trees about them, as well as the stars that shine above us, and proclaim the majesty and wisdom of that God who made the earth and built the skies.†

We have thus been led by the recognition of a uniform

* For extended and interesting details, consult *Religion and Chemistry* by Prof. J. P. COOKE, pp. 271-274, and *Geometry and Faith* by THOMAS HILL, pp. 77-88.

† The perfect phyllotactic law is not of practical importance in the growth of plants; they live and flourish on the rudest approach to it. But the tracing of these approximations up, in such very numerous instances, to the highest degree of accuracy, such as 55:44 and 34:89, one above, the other below the perfect, shows that the law of extreme and mean ratio is actually incorporated into the vegetable kingdom. The builder of the plant knew that law untold ages before the geometer invented it, to inscribe a pentagon.—Pres. THOMAS HILL, *Geometry and Faith*, p. 88.

mathematical law, from the plants to the planets, from the vegetation which clothes the earth, to the stars that shine in heaven. And the connection is obvious; for all vegetation and fruitfulness depend upon "summer and winter, seed-time and harvest;" and these are regulated by planetary motions, accomplished in strict accordance with mathematical law. This leads us to notice the presence of

ARITHMETIC IN CELESTIAL TIME-KEEPING.

A time-piece, perfectly constructed and adjusted according to the laws of horology, keeps accurate time without intelligence or understanding. But is there no intelligence involved in the construction and adjustment of such a time-piece? A certain man had a watch which would not keep time. He carried it to a watch-maker, who examined it and pronounced it all right; still it would not keep time. He carried it from watchmaker to watchmaker, but none of them could point out any defect in its machinery, and none of them could make it keep time, or correctly mark the passing hours, keeping step with the motions of the earth and sun and stars; until at length one careful man *counted the cogs in every wheel in the watch*, and found that there was *one wheel which lacked one cog* of the proper number. Then the mystery was solved: all the watchmakers in the universe could not make a watch keep step with the stars, when a cog was missing from one of its wheels, or when a wheel had but fifty-nine cogs when it should have sixty, or only eleven cogs when it should have twelve.

A watch must run according to the law of its being; but the law of its being is only the embodiment of the will and *plan* and *intellect* of its *inventor* and producer, who reckoned the proper number of cogs needed in every wheel, and so arranged and combined them that the shafts which move the second, the minute, and the hour hands,

can only revolve according to mathematical law, at certain relative rates of speed, corresponding with the revolutions of the earth, the moon, and the stars, marking the passage of time in accordance with those revolutions.

The miscounting of a single cog is sufficient to thwart the purpose of the inventor of a watch, derange the whole programme, and render the watch useless. But the stars that shine above us are also parts of a great time-piece, which keeps the same time that is kept by our clocks and watches, only more accurately than any human mechanism can keep it. If the miscount of a single cog ruins the watch, what, then, of the miscounting of a single star? Can we, then, believe that this vast celestial time-piece, whose jeweled wheels count the passing seconds, and whose majestic pointers mark upon the dial of the skies, not only hours, days, months and years, but centuries and ages unnumbered and untold, is the work of blind, unreasoning chance, or lifeless, inactive matter; or that it was tumbled out of unorganized chaos by the throbs and struggles of unintelligent and unconscious force? Shall we not rather recognize in the mathematical precision which marks the movements of the universe, the presence of one omnipotent, presiding, Mathematical Mind, who "*telleth the number of the stars,*" and "*calleth them all by their names*"? Psalm cxlvii. 4.

When the French infidel said to the Vendean peasant, "We will pull down your churches, destroy your pictures, and demolish everything that reminds you of God," the peasant replied, "*But you will leave us the stars!*" And so long as the stars revolve and shine, so long the heavens shall declare the glory of God, and the firmament shall show his handiwork.

Chiseled upon a marble tablet in the wall of the Observatory at Williamstown College, are the words of Isaiah: "Lift up your eyes on high, and behold WHO HATH

CREATED THESE THINGS, that bringeth out their host by number: He calleth them all by names, by the greatness of his might, for that He is strong in power; not one faileth." Isa. xl. 26. This was the prophet's call to the skeptics of his time, and it is as timely to-day as it was then.

The French officers could dispute and deny the existence of a Creator, as they sailed down the Mediterranean beneath the splendors of the evening skies; but when Napoleon, wearied of their babble, pointed upward to the myriad stars above them and said, "All very well, gentlemen, but *who made all these?*" they were silent, as all atheists must be.

At not infrequent intervals, some pretentious scientist frightens the silly and simple-hearted by asserting that some wandering orb in its erratic flight is about to dash into this globe, and overwhelm the world in ruin. But the earth sweeps on in its orbit, and there have been no collisions yet. The myriad orbs that go careering through the skies, have never lost their balance or rushed staggering from their proper spheres. And can this order, regularity, balance, and stability, based upon mathematical law, be the effect of blind, unreasoning force?

The steam engine exhibits *force*, but it needs fuel to fire it, and a will to control and guide it. There must be a keen eye on the rails, and a firm hand on the lever; and back of all this there must be a central, calculating, planning, controlling, mathematical mind, a superintendent who counts the miles and counts the minutes, who knows the weight of trains, the power of steam, the speed of locomotives, and the value of curves and grades, and who gives the law by which trains are to be run. Talk of a universe run by chance, without regard to a guiding intelligence acting through mathematical law! You could not run a branch railway from Podunk Junction to Pug Hollow on such principles! A railway where trains were left to run by force and chance,

without mathematical control, would be strewed from end to end with derailed locomotives, wrecked trains, bruised heads, and broken bones. The boldest skeptic would fear to take passage on a railway train run without a controlling superintendent or manager, and without an intelligent engine driver, who would subject the train to mathematical law, as revealed in the time-tables established for its guidance.

And as the locomotive requires not only an inventor and constructor at the beginning, and a superintendent and driver to constantly direct and control it, so such a world as this indicates, in its constitution and order, not only the working of an omnipotent and omniscient Creator at the beginning, but the constant action of an omnipresent God, who rules and guides the destinies of creation, "upholding all things by the word of his power."

ARITHMETIC IN SPECTROSCOPIC REVELATIONS.

The recent revelations of the spectroscope, which by an arrangement of prisms and telescopes enables us to measure and analyze the spectrum, or magnified image of a ray of light resolved into its constituent colors, and thrown upon a screen; have enabled the observer to detect the presence of different mineral and chemical substances not only in the earth and air but also in the planetary bodies.

The presence of these substances is revealed by certain lines or bars of varied dimensions and colors, which cross the band of colored light in the spectrum; and these groups of lines are always arranged with *arithmetical uniformity* as to number, breadth and position; so that when, as in the investigation of celestial bodies, the different *colors* cannot be discerned to determine their chemical composition, in its stead the *grouping* and *number* of the bands and lines exhibited, shows clearly the

presence of some of the same materials in the sun and in the planets, which are known to exist upon this globe. These recent discoveries derive much of their value from the fact that *mathematical law* reigns supreme in the mineral and chemical world,—a fixed *number of similar lines* in a certain position always indicating the presence of the same substance in the source whence the light comes or in the medium through which it passes.*

In accordance with this fact may be recognized the universal prevalence and reign of

ARITHMETIC IN CHEMICAL SCIENCE.

The time would fail us to enter the realm of chemistry and show how all chemical combinations are subject to the exactest numerical laws—the law of Definite Proportion,† ensuring the exact uniformity of all composite

* For further details consult *The Errors of Evolution*, by Robert Patterson; Part I., *Scientific Star-Building*, pp. 62-71. ANTI-INFIDEL LIBRARY, No. 10.

† I have already defined a chemical element as a substance which has never as yet been decomposed, and all the matter with which man is now acquainted is composed of one or more of at most seventy elementary substances. When two of these elements unite together to form a compound body, the proportions in which they combine are not decided by chance. You cannot unite these elementary substances in any proportion you please. The proportion in each case is determined by an unvarying law, and the amounts required of either substance are weighed out by Nature in her delicate scales with a nicety which no art can attain. Thus, for example, 23 ounces of sodium will unite with exactly 35.5 ounces of chlorine; and if you use precisely these proportions of the two elements, the whole of each will disappear and become merged in the compound which is our common table salt. But if, in attempting to make salt, we bring together clumsily 23.5 ounces of sodium and 35.5 ounces of chlorine, Nature will simply put the extra half-ounce of sodium on one side, and the rest will unite. This law, which governs all chemical combinations, is known as the "law of definite proportions."—Prof. J. P. COOKE, *Religion and Chemistry*, p. 265.

Carbonic acid contains exactly twice as much oxygen in proportion to the carbon as carbonic oxide; the red oxide of mercury contains twice as much oxygen as the gray oxide, etc. Of the three oxalates of potash, the second contains twice as much acid as the first, and the third four times as much—the quantity of the base being equal. It is not always, however, that the relation is so simple as that of one to two, or one to four: two to three is very common; two to seven is sometimes met with, but rarely. Thus of the oxides of iron we have protoxide, 28 parts of iron and 8 parts of oxygen: sesquioxide, 56 parts iron and 24 parts oxygen; and ferric acid, 28 parts iron and 24 parts oxygen.—*Chemistry as Exemplifying the Wisdom and Beneficence of God*; a Prize Essay by GEORGE FOWNES, Ph.D., Appendix ix.

chemical substances; the law of Combining Proportion, according to which, when the same elements combine with each other in different fixed mathematical proportions to produce different substances, in these varying proportions all the highest combinations are always *exact multiples of the first*; and the law of Reciprocal Proportion, by which, if two bodies will combine in certain proportions with a third body, they will combine in the same exact proportions with each other.

To attempt an enumeration of the arithmetical relations of inorganic substances, would be to rewrite the latest works on chemistry, and rehearse facts to which schoolboys have easy access. Suffice it to say that in the universe of matter in all its combinations, mathematical law is supreme and all-prevading. Every known composite substance is compounded of its various constituents combined in *definite proportions* fixed by unvarying *mathematical laws*, more accurate than any human formulas which regulate the formation of artificial chemical compounds; and all these elements combine in strict accordance with their atomic weights.*

* Tables will be found in works on chemistry which give, opposite to the name of each elementary substance, a numerical value, usually called its atomic weight, and in all cases, where the elements are capable of combining with each other, they either unite in the exact proportions indicated by these numbers, or else in some simple multiple of these proportions.

The following are the atomic weights which are believed to have been determined with the greatest accuracy:

Aluminum.....	27.02	Hydrogen.....	1.00	Potassium.....	39.14
Antimony.....	120.00	Iodine.....	126.85	Phosphorus.....	31.05
Barium.....	137.14	Lead.....	206.99	Silver.....	107.93
Bromine.....	79.95	Lithium.....	7.01	Sodium.....	23.05
Calcium.....	40.00	Magnesium.....	24.00	Sulphur.....	32.07
Carbon.....	12.00	Nitrogen.....	14.04	Thallium.....	204.11
Chlorine.....	35.46	Oxygen.....	16.00		

These values are called atomic weights, because, according to our modern chemical theory, they represent the relative weights of the ultimate atoms of the elements. If this be the case, it is evident that when the atoms group themselves together to form the molecules of various substances, the elements must combine by whole atoms, that is, in the proportion of the atomic weights, or of a simple multiple of these proportions; and thus this atomic theory explains the law of definite proportions.

In connection with this table a most remarkable fact should be noticed, which

And this is not only true of substances which are combined chemically, but also in cases where the combination is simply mechanical.

Thus, for example, atmospheric air, which is not a chemical compound, but simply a mechanical mixture of various gases, is known to be *uniform* in its *composition* in all parts of the world. Though analyzed hundreds of times, in all climates and latitudes, its composition has been found to be uniformly the same.

Consider how much this implies. A cubic yard of space in this latitude, at the sea level, ordinarily contains about two pounds of atmospheric air. As we ascend from the level of the sea, of course the air diminishes in density, but its constituents remain the same. In ten thousand pounds of atmospheric air there will be 2061 pounds of oxygen; 7795 pounds of nitrogen, 4 pounds of carbonic dioxide, and on an average, about 140 pounds of watery vapor. Beside this, there will be infinitesimal traces of nitric acid, ammonia, and carbureted hydrogen. Now these different substances, having different qualities, are so intermingled and so balanced that they constitute atmospheric air. And though for ages mankind were unconscious of the existence of such a substance, yet modern science discloses the fact that in the atmosphere surrounding our earth, there is 1,233,000 billions of tons of oxygen, 3,994,593 billions of tons of nitrogen, 5287 billions of tons of carbonic dioxide, and 54,460 billions of

indicates the deep significance of this series of values. They are all mutually dependent, so that the same numbers which represent the proportions in which two elementary substances combine with the same quantity of a third substance, represent also the proportion, or a multiple of the proportion, in which they combine with each other. Thus not only do 16 parts of oxygen combine either with 12 parts of carbon or with 14 parts of nitrogen to form in the first case carbonic oxide, and in the second case nitric oxide, but also 12 parts of carbon combine with 14 parts of nitrogen to form cyanogen; and the same principle holds for the other weights given in the table, whenever the elements are capable of combining, although, in most cases, only the multiple values appear in the formation of known compounds.

—Prof. J. P. COOKE, *Religion and Chemistry*, pp. 266-268.

tons of watery vapor; the whole vast number of *tons*, utterly beyond the scope of human thought or imagination, being expressed by the figures 5,287,350,000,000,000.

In all this entire mass of atmospheric air, the weight of which can be experimentally demonstrated, may be traced an accurate *uniformity of composition*; and though the whole arrangement is conducted on a scale of such vastness and immensity, yet with the exception of the *watery vapor*, which increases and diminishes from time to time, the other ingredients of the atmosphere maintain their *absolute uniformity* and exactness of proportion.

What proof could be more convincing than this, that the world in which we live is superintended, ruled, and controlled by some Being who possesses not only almighty power, but also a contriving, combining, *mathematical mind*, and who works according to strict mathematical law, whether in the minutest details, or in operations of such immensity that only an Omniscient Mind can comprehend their amazing magnitude?

In view of the countless numerical marvels at which we have only been able to hint, but which pervade the entire universe, and which are discernible by all who have eyes to see; we cannot resist the conclusion that behind all these mathematical mysteries, many of which lie too deep for human comprehension, there exists not only an Almighty Arm which upholds and controls the universe, but an Omniscient and Mathematical Mind, which comprehends every marvel, and grasps every mystery;—the mind of Him who “searcheth the reins and heart.” “Neither is there any creature that is not manifest in His sight; but all things are naked and opened unto the eyes of Him with whom we have to do.” Heb. iv. 13.

CHAPTER III.

MATHEMATICS AND MUSIC.

It is a curious fact that music, which apparently bursts forth free as the wild carols of the birds in the air, and which would seem to have no connection whatever with dry, mathematical details, is found on investigation to be based upon and ruled and governed by the most precise and accurate mathematical laws.

What we call sounds or tones are but vibrations of air, or sound-waves, beating upon the tympanum or drum of the ear. Hence the existence and perception of musical sounds depends first upon the production at regular intervals, by appropriate mechanical devices, of sound-waves, or certain agitations or vibrations of air; second, upon the existence of some medium which is capable of transmitting such vibrations from one place to another; third, upon the mechanical adaptations of the ear to perceive such sounds, and distinguish between those produced by vibrations occurring more or less frequently. And all these requisites to the production and transmission of sound result from mechanical contrivances and arrangements, which conform to the strictest mathematical law, and can only be expressed by mathematical signs and emblems.

For example, if we strike the middle C key upon the key-board of a piano tuned to the *Classical Pitch* which

prevails substantially in Europe and America as a vocal standard, we shall find, by using the sirene, or other proper instruments for measuring musical vibrations, that these vibrations fall upon our ear at the rate of 264 per second. The "vibration number" of middle C is therefore 264. Now if we strike a longer and heavier string, which sends only half as many sound-waves to the ear in a second, we shall find that this sound is also C, an octave below the first. If we subdivide the "vibration number," and find a string which gives but 66 vibrations per second, that sound will be C, an octave lower. On the other hand if we double the number of vibrations produced by middle C, then the 528 sound-waves per second give us C again, an octave above middle C; and so on to the highest audible musical sound.*

The largest modern organs have $16\frac{1}{2}$ for their lowest vibration number; but there is very little music in sounds below the lowest note of the double bass, which gives $41\frac{1}{2}$ vibrations per second. On the other hand, the shrillest sound in the orchestra, the highest note of the piccolo flute, P_6 , has 4752 vibrations per second. The human voice is able to compass tones ranging from 100 to 1500 vibrations per second, though no single voice could produce all these. Ordinary chorus voices are said to produce tones ranging from 100 to 900 or 1000 vibrations each second, and the human ear is said to be able to

* Every one who has dropped a stone into the water of a still lake has noticed the system of waves which, with its ever-increasing circles, spreads in every direction from the stone; but all may not know that when two stones are struck together in the air a similar system of aerial waves spreads, in ever-widening spheres, through the atmosphere, and that it is these waves breaking on the tympanum of our ears, like the waves of water on a sand-beach, which produce the sensation we call sound. Two stones thus struck together give rise to waves of unequal size, following one another at irregular intervals; and such waves produce an unpleasant sensation on our auditory nerves, which we call noise. But if, instead of striking together two stones, we set in vibration the string of a piano-forte or the reed of an organ-pipe, we excite a system of waves, all of equal size, and succeeding one another with perfect regularity, and these breaking on the ear produce by their regular beats what we call a musical note.—Prof. J. P. COOKE, *Religion and Chemistry*, pp. 38, 39.

distinguish eleven octaves, reaching from $16\frac{1}{2}$ to 38,000 vibrations per second.*

It will be seen from these facts that the difference of *one vibration per second* must produce a difference in the pitch of a tone, but such differences would of course be too small to be perceptible. It is estimated that an ordinary musical ear hears from one to two hundred sounds in an octave, or a thousand different shades of sounds in the whole scale; while trained violinists are said to be able to distinguish about 700 sounds in a single octave, or nearly 5000 in all.

Now if we take any one of these four or five thousand sounds that can be produced, and fix upon it as a *tonic*, or key-note, we can find its octave through the whole scale, by simply multiplying or dividing the number of its vibrations by two; and wherever we find a sound caused by any definite number of vibrations, any string which will produce twice, four times, eight times, or sixteen times as many vibrations in a second, will give the *octave of that note*; and all those strings, touched at the same time, will produce concordant sounds, which will be smooth, pleasant, and agreeable to the ear, because the sound-waves adjust themselves to each other, and at brief intervals coincide, and so strike the ear together.

But if we strike a string whose vibrations are one

* Sounds of the highest pitch, like the cry of some insects, become disagreeable, and by some persons cannot even be distinguished. It is quite possible to produce a sound, which, though painfully shrill to one person, shall be entirely unheard by another. Professor Tyndall, in his very interesting work on the glaciers of the Alps, relates an instructive anecdote of this sort, which I give in his own language:

"I once crossed a Swiss mountain in company with a friend; a donkey was in advance of us, and the dull tramp of the animal was plainly heard by my companion; but to me this sound was almost masked by the shrill chirruping of innumerable insects, which thronged the adjacent grass; my friend heard nothing of this; it lay quite beyond his range of hearing."

There may, therefore, be innumerable sounds in nature to which our ears are perfectly deaf, although they are the sweetest melody to more refined senses. Nay, more, the very air around us may be resounding with the hallelujahs of the heavenly host, when our dull ears hear nothing but the feeble accents of our broken prayers.

—Prof. J. P. COOKE, *Religion and Chemistry*, pp. 40, 41.

eighth more frequent than those of the note which we have selected as a key-note, we have what is called a *second*, which is a discord, sounding roughly and unpleasantly. So if we strike a string which causes sixteen vibrations while the key-note gives but nine, we have what is called a minor seventh, which is also a discord. And if we strike a string which vibrates fifteen times to every eight of the key-note, we have still another discord, called the major seventh.

We here present on a musical staff the major and minor intervals of the musical octave, under each of which is given its *vibration number*; the scale commencing with middle C; while beneath each note is placed its *vibration fraction*; the upper figure showing the ratio of vibrations in the note above it to the vibrations of the key note, middle C, as expressed in the lower figure of the fraction.

Concord. Discord. Concord. Concord. Concord. Concord. Concord. Concord. Discord. Discord. Concord.

264	297	316½	330	352	396	422⅔	440	469⅓	495	528
1	2	3	4	5	6	7	8	9	10	11

Now if two instruments, both in perfect tune, be played together, one sounding only middle C, and the other running up through the whole scale, we shall find that there will be *nine* vibrations of D to every *eight* of C, *five* vibrations of E to every *four* of C, *four* vibrations of F to *three* of C, and *three* vibrations of G to *two* of C. It will be seen at once, that in the case of these tones which are concordant, the sound-waves correspond and coincide with each other at intervals of two, three, four, or five vibrations of the sound-waves of the key-note, middle C. But in the case of the *discordant* notes, *eight* or *nine* vibrations of the key-note must occur before a single sound-wave of these discordant notes will

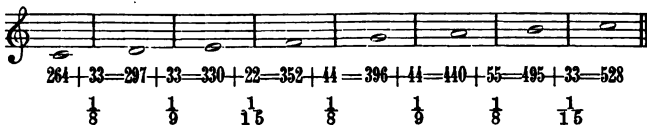
coincide in time, or strike the ear simultaneously with one of the sound-waves of the key-note; hence these notes necessarily produce inharmonious and unpleasant sounds, possibly something as flickering lights disturb the eye.

As the untrained human ear fails to recognize all the delicate shades of the pitch of musical sounds, so the human voice fails to imitate or embody them, but rises and falls from any given tonic or key-note, in steps of unequal length. Among uncultured nations, these steps are few; while under the influence of culture the ear becomes more acute, the voice more thoroughly trained, and the intervals more numerous. Had these steps been precisely equal, music would have lost one of its chiefest charms, for to the inequality of these musical intervals we owe the existence of the different *keys* of music, with their endless variety of shadings and effects; all of which are based upon the strictest mathematical principles.

We here present as an illustration of this, the following musical staff, containing the eight notes; and give under each note the vibration number of that note, commencing with 264, the vibration number of middle C.

After each *vibration number* another number is given which may be termed the *vibration interval* between the two notes. This interval marks the difference in the number of vibrations per second between each note and the note next above it, and thus indicates how the 264 vibrations between middle C and its octave are divided in the ordinary scale. The vibration *interval* between C and D is 33, which is $\frac{1}{8}$ of the vibration number of C; between D and E it is 33, which is $\frac{1}{9}$ of the vibration number of D; between E and F it is 22, which is $\frac{1}{15}$ of the vibration number of E; between F and G it is 44, which is $\frac{1}{6}$ of the vibration number of F; between G and A it is 44, which is $\frac{1}{9}$ of the vibration number of G; between A and B it is 55, which is $\frac{1}{5}$ of the vibration

number of A; and between B and C it is 33, which is $\frac{1}{16}$ of the vibration number of B.



It will be seen then that in this musical scale or gamut, arranged in accordance with the natural workings of the human voice, and without any thought of the underlying mathematical principles, these unequal vibrations occur in strict mathematical order.* Three of these intervals are marked by a difference of 33 vibrations per second in the sound-waves, one by a difference of 22 vibrations, two by a difference of 44 vibrations, and one by a difference of 55 vibrations. The basal number of all these is eleven, which number is contained twice in 22, three times

* The standard of musical pitch is purely arbitrary, but the capacities of the human voice limit the range of vocal tones within narrow bounds. Instruments are not thus limited, and are often tuned to a higher pitch; hence the standards of pitch for vocal and instrumental music have often varied. To harmonize these, early in the seventeenth century a *Mean Pitch* was established, which was maintained with much uniformity, varying only about half a semi-tone for two centuries, during which the great musical masters, Bach, Handel, Purcell, Hayden, Mozart, and Weber, lived and wrote, and Spohr, Mendelssohn, and Rossini, commenced their career. This standard is called the *Classical Pitch*, and is substantially represented by Handel's tuning fork, which is still in existence.

The prominence of wind instruments in orchestral music, and the ambition of manufacturers to produce brilliant effects, led them to raise the standard of pitch in their instruments; hence, *Concert Pitch*, which is sometimes a tone higher than *Classical Pitch*, is largely used by orchestras; but it is repudiated by vocal performers as strained and unnatural to the voice, changing the character of the great body of classical music.

In 1834, a Congress of Physicists, held at Stuttgart, adopted the proposition of Scheibler, and recognized a standard of pitch which fixes 264 as the vibration number of C below the staff, or middle C on the piano key-board. In 1869, a committee appointed by the Society of Arts in England, recommended the same standard, which is represented by the Normal Tuning Fork at Stuttgart, and is only a little more than a hundredth part of an octave higher than the vibration number 261, legalized by the French government in 1859. The calculations here given are based upon this natural or *Classical Pitch*, which is substantially that used by all the great masters, 264 being taken as the vibration number of middle C on the piano key-board; the C on the ledger line below the treble staff.

in 33, four times in 44, and five times in 55. The more frequent interval is 33: 22 and 44, which stand side by side, make 66, which is twice 33; 44 and 55, which stand together, make three times 33, or 99; while twice 44, and also 55 and 33, each make 88, which contains eight times eleven, or twice 33 and twice eleven.

We may proceed still further, and we shall notice that this same *eleven* is the basal number of all these *vibration numbers*. Thus 264 contains 24 elevens; 297 contains 27 elevens; 330 contains 30 elevens; 352 contains 32 elevens; 396 contains 36 elevens; 440 contains 40 elevens; 495 contains 45 elevens; and 528 contains 48 elevens; and this number is the basal number of the vibrations of the octaves of *all these tones*, however high or low they may be, from $16\frac{1}{2}$, which is eleven and half of eleven, up to the highest octave discernible by the most sensitive and accurate ear.

Furthermore, the minor intervals in the scale, as shown in the first staff presented, are also multiples of eleven; but as the numbers of vibrations are fractional, the division by eleven shows a small fraction, which is exactly or very nearly the same as the fraction of the vibration number. Thus the vibration number of the *minor third*, which is $316\frac{4}{5}$, contains $28\frac{4}{5}$ elevens; the vibration number of the *minor sixth*, which is $422\frac{2}{5}$, contains $38\frac{2}{5}$ elevens; while the vibration number of the *minor seventh*, $469\frac{1}{5}$, contains $42\frac{3}{5}$ elevens. These illustrations show that this prime basal number lies at the foundation of all music; though the writer is not aware that attention has ever before been called to this fact by any writer or teacher of musical science.

Now all melody and harmony, and the entire science of music, with its countless combinations of varying sounds and chords, rests upon these simple mathematical principles, which govern the carols of the birds, the hum of

insects, the lowing of beasts, the sighs of zephyrs, the wailings of the winds, the thunderings of Niagara, the hymns of saints on earth, and the anthems of the seraphim around the throne of God. And vocal and musical organs in all created things are constructed with reference to the production of these sounds in accordance with mathematical law. And all these arrangements are made with direct reference to the density of the air, which itself is accurately compounded of elements which differ in density, and which must be united in certain exact mathematical proportions in order to properly convey musical tones.*

It must be remembered that these mathematical principles which govern all musical sounds, also have respect to the ear, which is so planned and constructed as to receive and discern these different sounds. And the

* Two gases, intermingled, remain to a certain extent independent of each other; and, inasmuch as sound travels in each gas with a velocity proportioned to the density and elasticity of that gas, there will be, from a single source of sound, two sounds propagated in the mixture, with different velocities, interfering with each other, and destroying the pure tone of a musical sound. Now the atmosphere is a mixture of heavy oxygen with lighter nitrogen. The elasticities are, however, so nearly adjusted to the densities, that sound travels in either gas with nearly the same velocity, so that the air sounds in an organ pipe as if one gas. Had sound traveled in these two gases at rates differing as much as the rate in them differs from that in most gases known to us, the use of wind instruments would have been impossible; probably all music, even the tones of the human voice, would in that case have been discordant to an ear at any considerable distance from the source of sound. With the intense and elevating character of the pleasure derived, first from the tones of human speech, from the melody of birds, and other natural music, and secondly, from the art of music, in our minds we cannot but be grateful for this adaptation of the mingled atmosphere to the needs of man in his higher nature.—Pres. THOMAS HILL, *Geometry and Faith*, pp. 12, 13.

As the air is now constituted there is constancy of pitch, however far sound travels. Any tone once generated remains the same tone till it dies away. Its degree of loudness alters in proportion to the distance of the listener, but the *pitch* is constant. Were the atmosphere not perfectly homogeneous, and the gases of which it consists even partially separated, there would have been a very different result. The constancy of pitch could have been no longer depended upon. The sound as it traveled would vary its pitch with the ever-varying medium through which it passed, and would arrive at the ear with a tone entirely different from that with which it started. Nor would it require any great difference in the medium, to confuse all those delicate differences of pitch upon which the whole art of music depends.—Prof. J. P. COOKE, *Religion and Chemistry*, p. 76.

ear itself contains a musical instrument of the most exquisite construction.

A writer in the *Physico-Medical Recorder* furnishes a description of a harp, "or rather a pair of harps in the human body, which are estimated to contain 8700 strings each. They are situated in that portion of the internal ear called the 'cochlea,' which has the form of a snail's shell, having a canal an inch and a half long, making two and a half turns about a centre-post called the modiolus. The harp strings are, of course, microscopic, their length ranging from $\frac{1}{800}$ to $\frac{1}{200}$ of an inch. Their discovery is due to recent anatomical and physiological research, and they have been called the 'Organs of Corti,' in honor of their discoverer.

"Passing the parts of the external ear, which are so admirably adapted to the purpose of conveying sound to the internal ear, we have the 'membrana tympani,' or 'drum,' which is tightened or relaxed, similarly to the head of an ordinary drum, by the bones and muscles of the internal ear. By means of these the sounds received, and the capacity to appreciate sound, are greatly modified. Every stringed instrument must have a frame and sound-box of firm, close-grained material. These qualities are furnished in the Organs of Corti. The cochlea, in which the strings are hung, is hollowed out of the petrous portion of the temporal bone, which is the hardest piece of bone in the body. The strings themselves are of a structure which has the consistency of cartilage, and each has connected with it a terminal filament of the auditory nerve.

"Thus all the requisites of a harp are present in the cochlea. An example will indicate how this wonderful harp is played. Hold a properly tuned violin near a piano while the latter is being played upon. When E is struck upon the piano, the E string of the violin will vibrate and

sound, as will the other strings when their corresponding tones are struck upon the piano. The 8,700 strings of this human harp have such a wide compass that any appreciable sound has its string of a corresponding tone, and the sound is conveyed through the connecting filament *to the auditory nerve*, and thus a knowledge of the sound is received by the mind."

Thus by careful investigation we trace the vibrations of sound-waves from their source, through the conducting medium of the air, until they reach the inner ear, and communicate their vibrations to those wonderful harp-strings. Up to this point all is mechanical and intelligible; but when these vibrating harp-strings touch the filaments of the auditory nerve, we have passed beyond the reach of science or mathematics, we stand face to face with the problem of life and sensation, a problem which no mortal has ever been able to solve or explain.

Leaving this mysterious link between life and matter, and coming back to the comprehensible realms of mechanics and mathematics, we can plainly see that all these intricate and far-reaching combinations could only be effected by the highest intelligence, working in the realm of the purest mathematical science, and the results could never be produced by blind chance, or haphazard experiment. The principles involved lie too deep, and man, with all his wisdom, has only begun to comprehend them; therefore the man who should assert that all these complicated arrangements are the product of mere blind blundering force, would simply give evidence that his mind was so obtuse that facts and arguments were alike beyond his comprehension. An ordinary mind, capable of comprehending statements and appreciating evidence, could not fail to see in these arrangements the marks of design and mathematical intelligence; and the more extensive his knowledge of the subjects in question,

the more forcibly the argument would impress his mind.

Nothing in this whole subject is more wonderful than this adaptation of the human ear to the recognition of musical sounds. This adaptation is by no means universal; there are many persons who have excellent hearing, who cannot tell one tune from another, and who cannot sing in harmony. There are others who perceive no discords; to them music is only noise. There are others who delight in musical sounds, who detect the slightest discords, and who, having once heard a strain of music, can immediately imitate it, and perhaps never forget it.

Now the difference between the musical and the non-musical ear, consists in the presence or absence of the power to instantly recognize the musical effect of the difference between the vibration numbers of the various notes in the scale. Melody and harmony result from the production of a certain number of sound-waves which strike the ear in a second; discord and jargon result from the same sound-waves striking the ear in different numbers, or from vibrations at a different rate of speed. In what way can a child of three years, who knows nothing of sound-waves or vibration numbers, discern accurately these concords and discords? Who has constructed this sound-measuring instrument, so delicate, and so capable of unconsciously detecting and proving intricate mathematical combinations, without instruction or training? There are the mathematical elements; there are the sounds which fall on the ear of a child in accordance with the strictest and most intricate mathematical laws; the ear of a child instantly recognizes the result of the whole, and can detect any appreciable error; but what is the difference between such an ear and another ear which has no such powers?

Here, for example, are a hundred singers, strangers to each other, arranged together. The leader touches the key

of middle C on a piano which has been accurately tuned to produce 264 sound-waves to the second. Instantly that whole company of singers imitate that sound: that is, in some mysterious way, they adjust their vocal chords to produce 264 sound-waves per second. He strikes another note, G, and at once the vocal organs of each of those singers are so readjusted as to produce 396 vibrations or sound-waves per second. He strikes another tone, the octave of the first, and at once the singers respond by adjusting their vocal chords to produce 528 sound-waves per second; and if any voice fails to produce the requisite number of sound-waves, the musical ear at once detects the error. But at the same time a hundred other voices may adjust themselves to produce other sounds which shall chord with the sounds produced by the first hundred singers, and their ears will detect any lack of *concord* in those sounds. And so four or five companies of singers will be singing at once, each company producing different and yet concordant sounds; each person in these companies passing at pleasure through the range of one, two, or three octaves, and producing with the rapidity of the quickest speech, these changeful numbers of sound-waves, and instantly detecting every discord and every concord in tones, all of which depend upon the nicest mathematical combinations; and yet all this is done by persons, both young and old, who know nothing of mathematics, who understand nothing of the laws of acoustics, who never heard of a sound-wave or a vibration number, and yet who, by some mysterious power, work out these subtle mathematical problems to perfection, enjoying and communicating to others the intensest pleasure: while other persons right beside them, having equally acute hearing, cannot distinguish one musical sound from another, and find no pleasure in them.

Can such organs, so constructed and adapted, be the

result of blind unreasoning force, or blundering, unconscious chance? To minds who could imagine such im possibilities, how appropriate are the words of the Psalmist, "Understand, ye brutish among the people: and ye fools, when will ye be wise? He that *planted the ear, shall he not hear?* He that formed the eye, shall he not see? He that chastiseth the heathen, shall he not correct? He that teacheth man knowledge, shall not He know?" Psa. xciv.

The facts in musical experience have been recognized for ages among all nations to a greater or less extent. Men have made music, heard music, enjoyed music, written music, harmonized music, and invented and constructed musical instruments for ages, in general accordance with these facts and principles, before they had the slightest suspicion of the mathematical laws which underlie the whole science of music, and which rule the anthems of the angelic hosts, the celestial harmonies of the seraphim, and all the strains of melody which brighten this world of darkness, weariness, and tears.

INSTRUMENTAL MUSIC.

It is to our ignorance and neglect of these fundamental mathematical laws of sound, that we are indebted for much of the mysterious jargon which passes for "music" at the present time. Well-trained human voices are capable of producing every musical sound within their compass; and of gliding up and down the entire range of musical tones, which shade and blend imperceptibly, as the sound-waves multiply or diminish. Hence melodious human voices, softened by the rich emotions which fill the renewed heart, can produce the sweetest, purest, most melodious and harmonious strains; and the music of human voices, carefully trained *without instrumental accompaniment*, is unapproached and unapproachable by instruments of music, only two or three of which admit even of delicate shadings of pitch, to say nothing of purity

of tone, in which the voice is entirely unequalled. The whole rabble of keyed instruments are ingenious devices for debasing the human voice and vitiating the accuracy of the human ear, and producing sounds which *can not* be perfectly harmonious even when in tune; and when "out of tune" the evil is proportionally aggravated.

For example, if ordinary chorus voices can produce sounds ranging from one hundred to one thousand vibrations per second, then such voices can produce nine hundred distinct shades of sounds. Thus in ranging from middle C, with its 264 vibrations to the second, to the octave above with its 528 vibrations, there are 264 different shades of pitch; and in the next octave above the number is doubled; while the piano, organ, or harmonium, has a key-board containing only *twelve notes* in each octave. But to play *perfectly* music in the seven keys, C, D, E, F, G, A, B, in both major and minor modes, twenty-six notes would be needed in every octave. Modern music is also written in sharp and flat keys, and the sharp and flat keys are different from each other. The vibration number of G $\sharp$ is $412\frac{1}{2}$, but the vibration number of A $\flat$ is $422\frac{2}{3}$, yet these in the organ, harmonium, and piano, must be played on the same pipe, string, or reed. Mr. A. J. Ellis, after careful investigation, asserts in the *Proceedings of the Royal Society* (vol. xiii. 98),* that to get complete command over all the keys used in modern music, would require an instrument having *seventy-two notes in each octave*. But no such instruments exist, and who could play them if they did? In the vain effort thus to represent on an average *six different sounds* by each individual *note on the key-board*, and by thus vitiating the human ear, and debasing and corrupting the vocal tones to bring them into unison with such

*See *The Science of Music, or The Physical Basis of Musical Harmony*, by Sidney Taylor, M.A., p. 157.

defective instruments, men produce a kind of music which is fearfully and wonderfully made, by singers who always practice and perform with instrumental accompaniment; a music which fails to express the deep emotions in the heart of the singer, or to awaken corresponding emotions in the mind of the hearer, if indeed the singer has emotions to express, or the hearer emotions to be awakened. But as the organ thunders on, and drowns both melody and harmony in its ceaseless droning, it makes comparatively little difference how the singers use their voices, since their words are unintelligible, and their tones are often a babel of untrained, unmusical, discordant janglings. If nine tenths of the musical instruments now in use could be sent into oblivion, and if singers could be converted to God, and then *trained* in voice and ear, *without* the debasing brawl of instrumental accompaniment, or with instruments tuned and used to play music only in a single key, we might have examples of melody and harmony which we are never likely to have in connection with ordinary musical performances.

While man's musical instruments cannot reproduce the myriad grades and shades of musical sound, man's vocal organs are so carefully planned and constructed in accordance with mathematical and mechanical laws, that they can produce *every possible grade and shade of sound* within their compass. For the vocal organs can be mechanically and automatically adjusted to produce from *one hundred to one thousand* sound-waves per second, the adjustment varying to increase or decrease the number even by a single vibration per second. No instrument has ever been produced capable of such delicate adjustment; and the stringed instruments which so closely *follow* the tones of the voice, owe the nicety of their adaptation *not* to their construction or automatic action, but to the intelligent supervision of the skilled *player*.

who, by lengthening or shortening the vibrant strings, produces minute variations in tone.

We would not undervalue any of the great instruments of music which modern ingenuity has produced, and by means of which a single musician can approximately execute the different parts of some great musical masterpiece, which, without these instruments, could only be interpreted by an orchestra. Such instruments are indispensable for such a purpose. And untrained human voices, following such instruments, may approach greater correctness of tone than they might otherwise attain; yet after all, these instruments only approximate the purity of the divine standard, as embodied in the mechanism which the Creator has constructed for the production of musical sounds.

Heard by untrained ears and compared with uncultured voices, the sounds produced by instruments are often pleasing; and when heard singly, their imperfections are not readily detected. But when different notes are sounded at the same time, the defects in harmony are more readily perceived. And whenever musical instruments are allowed to drown and overshadow human voices, and whenever human voices are trained to *follow* and rely upon keyed instruments, the purity of the vocal tones must necessarily be debased, and the accuracy of the human ear vitiated, and music must lose its highest and purest charms. And though in fullness and volume keyed instruments often excel stringed instruments, yet in accuracy of shading, and in conformity to the natural tones of the human voice, these instruments are unapproachable. And this may be the reason why the violin exercises such a witchery over its votaries; for it is well known that a person thoroughly enamored of the violin, is likely to be of little use except to play upon it. Hence the Scriptures speak in warning tones to those who “chant

to the sound of the viol" (Amos vi. 5), and utter solemn reproofs to those persons in whose feasts "the harp, and the viol, and the tabret, and the pipe, and wine" have place. Isa. iv. 12. And thus God says to his apostate people, "Take away from me the noise of thy songs, for I will not hear the melody of thy *viols*; but let judgment run down as waters, and righteousness as mighty streams." Amos v. 23, 24.

It is well known that the early Christian church for many centuries employed no instruments in the worship of God; and the early fathers, almost with one accord, protest against the use of such instruments. And many Christians have claimed that they were only needed and sought after when pure spiritual worship had fallen into decay. But whatever view may be adopted concerning these matters, the careful listener cannot fail to notice the incomparable superiority of the pure and unperverted human voice, over the imperfect instruments which men have hitherto invented. This difference between the natural tones of the human voice and the defective imitations produced by instruments, may explain why some tunes we hear *sung*, move our very hearts, while the same tunes "performed" upon, or accompanied by, an instrument, fall upon the ear, dull, flat, tasteless, and discordant.

A friend who formerly sang in vocal concerts informed the writer that their leader would never allow them, when rehearsing or singing, to use *either instruments or books*. They were required to use their *voices* and their *ears*, and were not allowed to have their attention diverted by other things. Any person who will listen to the singing of a choir, and to the music which accompanies it, will, unless one is entirely drowned by the other, clearly perceive the lack of harmony between the vocal and instrumental sounds. If the time spent in twisting human voices into unison with the sounds made by strings, and pipes, and

reeds, which are never in perfect tune, and in so vitiating the human ear that it cannot discern the difference between discord and harmony, were spent in training both voice and ear to produce and appreciate a style of music, pure, natural, devout, and sympathetic, the result would be a new revelation in the realm of musical sounds, which would astonish musicians, and thrill the listeners' hearts.*

Of course we cannot expect, nor could ordinary ears appreciate, absolute perfection in musical sounds; but when we learn what hidden principles underlie the whole system of musical tones, we shall then understand *why* much that passes for music gives neither peace nor pleasure; and why many old-fashioned people take little interest in the sounds of "the harp, sackbut, psaltery, dulcimer, and all sorts of musical instruments," which so often destroy harmony, interrupt devotion, and allow godless worldlings to exhibit themselves as leaders in the worship of the Almighty, producing sounds which doubtless distress the angels as much as they grieve the saints.

We shall never know what true music is until we conform to the perfect mathematical laws of melody and harmony. This may never be done in this world. Earth's instruments are out of tune, and no one can tune them perfectly; every variation of temperature changes their pitch and exhibits their imperfection; but that which is perfect will come by and by; and when the angels of God shall gather around the throne of glory; when the redeemed shall come with palms, and crowns, and harps; when the song of the ransomed shall rise like the

* In the preface to the Stoughton Musical Society's *Centennial Collection*, is recorded a tradition of an exhibition of musical talent which occurred at Dorchester, Mass., about the year 1790. The Dorchester choir of male and female singers, with instrumental assistance, having invited the trial, after singing their choicest strains, yielded the palm to a selected choir of twenty Stoughton male singers, who sang *without book or instrument*, Handel's Grand Hallelujah Chorus, then recently published in America.

voice of many waters and mighty thunderings, and yet shall fall sweet as the music of "harpers harping with their harps;" we shall then see the difference between the true music, made in accordance with the mathematical laws which govern the universe of sound, and the blundering, hap-hazard musical jargon which vexes so many righteous souls in this world of discord and confusion.

We have glanced at the working of a single mathematical law, which lies at the foundation of musical science. But we have only touched the subject. There may be yet deeper principles, which we have only begun to comprehend. It is related that one great pianist, not content with ordinary musical sounds, found delight in all cries of pain and distress, as if by some wider grasp he was able to distinguish other tones and concords outside of the range of the ordinary mind, but which were embraced in his marvelous musical comprehension.

It is said that persons ascending above the surface of the earth, as they go higher and higher, catch the faint sounds of what men call discord; but which in the upper air are mellowed and softened till they blend in perfect harmony. So it may be that the Eternal Mind comprehends music where we see only discord, and that all earth's seeming turmoil and confusion, rises at last amid the music of the spheres, and falls harmonious on the ears of Him who maketh even the wrath of man to praise him; who worketh all things according to the counsel of his own will, and whose glory not only fills the heavens, but shall yet flood the earth, as the waters cover the sea.

CHAPTER IV.

ARITHMETIC IN VITAL ACTION. THE LAW OF SEVENS
RULING ALL LIFE. SABBATHS, SEPTENARIES, JUBILEES.
MARKS OF STYLE. TOKENS OF AN OMNIPRESENT GOD.

The reign of number in the universe is specially exhibited in the law of *weeks*, which governs animal life. Throughout the whole history of man, from the forty weeks which cover his embryotic existence, onward to the close of his life, the number *seven* rules his entire being. The periodic changes which occur in the human constitution in persons of *both* sexes, clearly indicate that man, in his birth, growth, development, maturity, vital functions, reproductive system, health, disease, life and death, is controlled by the *law of completion in weeks*. His very *pulse* keeps time with the seven-day period, so that, as Dr. Stratton's varied observations show, "the human pulse is more frequent in the morning than at evening, for *six* days out of the seven, and that *on the seventh day it is slower*;"* thus indicating that the number *seven* by a divine ordination rules the human constitution. The same thing is true of the myriad creatures that fill the earth. Dr. Laycock tabulated the periods of utero-gestation in the lower orders, and periods of incubation in birds, and after getting the most trustworthy observations practicable regarding *one*

* Edinburgh *Medical and Surgical Journal*, January, 1843.

hundred and twenty-nine specimens of birds and mammals, he found in *sixty-seven cases* the periods were a *definite* number of *weeks* or months, twenty-four others being *within a day* of the definite number; and the remaining thirty-nine were so loosely stated as to be of little weight, though most of them were favorable to his conclusion. He thus concludes, "The facts I have briefly glanced at are general facts, and cannot happen day after day, in so many *millions of animals of every kind*, from the larva or ovum of a minute insect up to man, at definite periods, from a mere *chance* or coincidence; and although temperature, food, domestication, and other modifying instances may and do interrupt the regularity with which the various processes I have alluded to are conducted, yet upon the whole it is impossible, I think, to come to any less conclusion than this, that in animals changes occur every three and one-half, seven, fourteen, twenty-one, twenty-eight days, or at some *definite number of weeks*."*

The skeptic may think lightly of the command that assigns to man one day in seven as a periodic *rest*. He may prefer the Decade of the French Revolution, or the occasional summer vacation; but when he has toiled on, regardless of physical and divine law, until at last he comes down upon the sick bed, with the typhoid fever; as his physician stands by his side and counts his pulse and reckons the passing days, he will learn that *his only hope of recovery and life* depends upon a favorable change which can only occur on the *seventh*, the *fourteenth*, the *twenty-first*, the *twenty-eighth*, or at the utmost limit the *thirty-fifth day* of his sickness. He may disregard the law of *sevens* in health, but it rules him when he is sick. France could abolish the Sabbath and introduce

* DR. LAYCOCK, in the *London Lancet*, 1842-3. See H. G. GUINNESS, *Approaching End of the Age*, p. 261, for numerous interesting facts and details.

the Decade, but all the physicians in France could not make a typhoid fever conform to their decades, nor cure a patient except in accordance with this *law of sevens*.

These facts have existed for ages, but men are slow to learn, and the skeptics who point out "the mistakes of Moses" in giving man one day in *seven* to rest, might perhaps profitably employ their leisure time in studying those mysterious peculiarities of the human constitution which conform to this wholesome law. They might also be able to explain why it is that the Jews who follow Moses' law live upon an average about a *third longer than their Gentile neighbors*; or why it is that the donkeys of London which *rest* one day in seven, can travel thirty* miles a day with their loads, while the donkeys which work seven days in a week, can only travel fifteen miles a day.*

The skeptic who despises and belittles Sabbatic rest as of no importance to *himself*, may perhaps see the utility of a system which gets thirty-six hundred miles' extra travel out of a donkey in the course of a year, and leaves him fresh and vigorous at the end. He who made man and made the donkey, knew what was good for them both; and the commandment which gave to man his rest, extended it not only to the son and daughter, the man-servant and the maid-servant, but also to the ox, the *ass*, and the stranger within the gates. Deut. v. 14. And the donkey who accepts his rest-day and lives, is wiser than the man who refuses and abuses it, and dies as the fool dieth. "Your Joss is better than our Joss," said the Chinaman to the British officer; "He gives you one day in *seven* to rest, while we get only *one day in a year!*" Imagine what life would be to toilers who cannot enjoy expensive vacations and pleasure trips, if they were

* See Lord SHAFTESBURY'S statement, quoted in *Remarks on "The Mistakes of Moses,"* by H. L. HASTINGS, ANTI-INFIDEL LIBRARY No. 6, p. 17.

robbed of their weekly rest-day, and set to the ceaseless toil and grind of unremitting care and labor for 364 days in a year. Would *such* a life be "worth living"?

The same number seven, when applied to years, also has its influence and bearing on human life. From the beginning of man's existence his life will be found marked off into septenary periods. The ages of seven, fourteen, twenty-one, are clearly marked. Forty-nine is a critical period in human history; sixty-three is another; while seventy, the *tenth seven*, marks man's three-score years and ten. And it is noteworthy that the Jewish law which made the seventh year of rest, was framed, as far as might be, in general accordance with this physiological law; and the forty-ninth and fiftieth years seem to correspond with that *double Sabbatic* and *Jubilee Year*, which marked the release of servants, the restoration of lands, and commenced a new cycle in the Jewish commonwealth.*

Thus these numbers, which lie before us on the very face of nature, though overlooked by all human lawgivers, are recognized in Scripture, and they indicate that He who filled this world with organic life, not only reckoned, and counted, and placed that life under the dominion of number, as expressed in days, and weeks, and years, but that that law which was given by Moses, and at which the scoffing world has never ceased to rail, embodied in it these mysterious principles of number, which men so long have failed to discern, but which indicate the presence of a Mathematical Intelligence, not only manifesting itself in guiding the creative energies which rule the world, but also in the giving of that matchless Law which came by Moses, as well as that grace and truth which is revealed in Jesus Christ.

* For statistics regarding Jewish health and longevity, see *Remarks on "The Mistakes of Moses,"* by H. L. HASTINGS, pp. 4-10, 21

CONCLUSION.

The various manifestations of mathematical law to which we have alluded are by no means singular or unusual. Similar principles are interwoven throughout the entire universe; and mathematical principles are so intertwined with the laws of acoustics, optics, mechanics, chemics, and physics, that it is impossible to separate them. And it is equally impossible to resist the conclusion that all these laws, in their multitudinous combinations and applications, spring from one supreme, mathematical Mind, and that some omniscient Mathematician planned these wondrous combinations which give to man such pleasure, comfort and profit. And the recurrence of special numbers in the varied departments of nature indicates the presence of a Mind which works according to well-established principles and familiar laws, dealing mainly with the simpler forms of number, which are presented as lessons adapted to the intelligence of His children; and going through higher ranges of mathematical thought, until the wisest are baffled and astonished at the majestic relations of mathematical law, as seen in the universal realm of nature.*

* The sacredness of the number three has been especially prominent in Christendom. The four elements of the ancients, and Erigena's fourfold division of nature, show the power of the points of the compass to impress their number on the human mind. The five digits of the hand, and the prevalence of fivefold divisions in the floral kingdom, give us the five-pointed star with its symbolism; point up for manhood and virtue; point down for beastliness and sin. The lily tribe gives us the six-pointed star; and six, a perfect number, in which the sum of the factors equals the product, is fitting as a symbol of the descent of the divine into the human trinity, the indwelling of God in man; the Perfect perfecting His child. The seven notes of the diatonic scale, the seven distinct colors, and other natural examples, fall in with the seven days of the week, the quartering of the moon's period. Jew and Gentile alike have hallowed the number seven; and no other number occurs so frequently with sacred associations in Jewish and Christian literature. Higher primes than seven do not enter much into our human thought, nor appear to be embodied in any part of creation known to us.

Music, painting, the coloring of nature and art, architecture, sculpture, drawing, the beauty of proportion and form,—how large a portion of our earthly pleasure and

Some persons will read these lines, who, had they no means of knowing their author, would yet immediately divine their origin. How they would do this they might be unable to explain; but they have for so many years been accustomed to read the productions of the writer's pen, that they would probably recognize the authorship; as they have often done before. A tailor can go into court and identify the stitches he has taken in a garment, though ordinary persons might perceive no difference between those stitches and the stitches of a thousand other tailors. But the tailor knows the difference; and others qualified to judge, and familiar with his handiwork, can also recognize the impress of his personality. A skilled ear, listening to the production of a musical composer, detects peculiarities of melody or harmony which no one else exhibits; idiosyncrasies of which the artist himself may not be conscious, but which, nevertheless, exist, and are all susceptible of analysis and classification.

These marks of *style* which attach themselves to the works of the author, the poet, the painter, the musician, and the mechanic, are also seen in the mysterious mathematics which rule the universe—in the number, the order, the beauty, the symmetry, the harmony, and the rhythm which pervade the world in which we live; and in them the careful observer may read the tokens of one great

spiritual culture depends on these; and these draw their charm in some mysterious way from the numbers two, three, five, seven. The number of prime numbers is unlimited; and since the first four give us, in the harmony of tones and colors, and in the proportions of form, such varied sources of high pleasure, such potent modes of spiritual expression, we may reverently hope that in the immortal life, the same beneficent Power which makes two, three, five, seven, thus minister to our joys below, will open to us more of the infinite treasures which lie hidden in the boundless fields beyond.—Pres. THOMAS HILL, *Geometry and Faith*, pp. 18, 19.

May we not hereafter add to these numbers the prime number *eleven*, which we have seen lies at the base of all musical science, and which thus is the instrument of one of the highest and purest pleasures of this world; a pleasure which shall survive the changes of mortality and enhance the glories of the life everlasting.

presiding Mind.* And while moles and blind men may see nothing but confusion and chance in the world, the anointed eye beholds the marks of creative mind; the anointed ear catches the echoes of Divine harmonies; and to the devout and observing soul, "the heavens declare the glory of God, and the firmament sheweth his handiwork," and all the mysterious and mathematical arrangements of the universe exhibit and demonstrate the presence and wisdom of an omniscient Creator.

We commend this somewhat neglected line of investigation to those searchers after God who have not yet learned to clearly discern His presence in the world which He has made. The subject is not one for superficial thinkers, but is worthy of the attention of the acutest reasoners; nevertheless it has certain departments which are within the reach of a little child. The simplest examples of

*Have you never recognized the composition of your friend in some anonymous literary article, by a peculiar phraseology, a turn of style, or a method of thought which no artifice could conceal? Have you never felt a glow of pleasure when you unexpectedly discovered on the walls of a picture-gallery the work of a well-known artist, marked by some peculiarity of grouping or coloring? Has your attention never been quickened when an orchestra has suddenly struck into a new theme of a favorite composer, never heard before, but unquestionably his? If you have experienced these or similar emotions, you know something of the force with which such numerical laws impress the mind of the student of nature, and you also know how difficult it is to make the power of such impressions understood. I wish I could give you a full conception of this power; for you cannot otherwise feel the full force of the evidence which these facts afford. They point directly to an intelligence in nature like our own, and they are a seal to the declaration of the Bible, that man was created in the image of his God.

The broken porticoes of the Parthenon still stand on the Acropolis at Athens to incite the imitation and win the admiration of the architect. The beauty of outline and those faultless proportions, which modern art has copied but never excelled, all depend on an exact conformity of all the parts to the laws of symmetry and to simple numerical ratios. We justly regard that ruined temple as the evidence of the highest intelligence; and when we find the same symmetry, the same numerical ratios, appearing everywhere in nature, how can we refuse to admit that they also are the evidence of intelligence and thought? Moreover, since the laws of symmetry and number pervade the whole universe, from the structure of the solar system down to the organization of a worm, they prove, if they prove anything, that the whole is the manifestation of the thoughts of the one great Jehovah, who "in the beginning" created all things by the word of His power.—Prof. J. P. COOKE, *Religion and Chemistry*, pp. 275, 276.

number in creation, are found like easy lessons at the very beginning of the book of nature; but persons who are competent to pursue the investigation, may push their researches into the mysteries of the higher mathematics, and there, standing amid the majestic grandeurs of the celestial universe, they will still recognize the reign of divine Omniscience and Omnipotence, embodied in mathematical law; and will plainly see that the same hand which paints the flowers, has built the skies; and that He who tuned the voice of the lark that carols in its morning flight, has also by the same laws ordained the songs of babes and sucklings who perfect his praise; the harmonies of the redeemed in glory; and the anthems of the morning stars.

Our eyes may be too dull to see God's majesty, which faintly shines in the myriad orbs that burn and gleam throughout His universe; our ears may be too dull to catch the celestial harmonies which unfold to us the very thoughts of God who has ordained them; but if our ears are once opened, and our eyes are anointed by Him, we shall then hear the celestial voices that speak to us from out this wondrous universe, and gazing with solemn awe upon His glory which beams through all the works which he has made, we shall say, like the wandering wayfarer, awaking from his couch around which angels watched; "Surely, the Lord is in this place, and I knew it not."

THE END.



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The undersigned, being personally acquainted with the Anti-Infidel Lectures and Publications of Mr. H. L. Hastings, of Boston, Mass., and believing that their wide circulation is demanded by the increase of Skepticism and skeptical literature, and will tend to greatly benefit not only Skeptics, but also all Christians and churches which hold the common faith of Christ, do hereby most heartily commend his work to the confidence, encouragement, and support of all Christians and Philanthropists.

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